REx

Residential Exposure Assessment Model

TECHNICAL GUIDE

Prepared by

infoscientific.com, Inc.

Prepared for

Organo Phosphates Case Study Group

April 2000

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1.0   INTRODUCTION

REx (Residential Exposure Assessment Model) is a spreadsheet[EXCEL] based exposure/dose assessment model that allows aggregating product use scenarios. REx is implemented in a user-friendly environment such that both simple deterministic and complex stochastic exposure and dose assessments can be made.

The product use scenarios in REx are those based on EPA's Residential SOPs draft document. One or more (up to six) scenarios can be aggregated to estimate exposure and dose to receptors of interest. Receptors included in this version of REx are adults and three categories of children (< 1 year, 1 year < age < 6 years, and age > 6 years).

Aggregation can be done for "day 0" during and post application scenarios.

2.0 PRODUCT USE SCENARIOS

The following scenarios are currently represented in REx:
- Lawn Care
- Vegetable Garden Care
- Ornamental Plant Care
- Tree Care
- Pick Own Fruits/Vegetables
- Crack & Crevice Treatment
- Termite Control
- Rodent Control
- Pet Care
- Outdoor Fogger Use
- Indoor Fogger Use
- Indoor Treatment
- Paint/Wood Treatment
- Impregnated Materials
- Detergent/Handsoap Use
- Swimming Pool Use
- Custom

3.0   EXPOSURE PATHWAYS & ASSESSMENT METHODS

The following are the receptor-specific (adult and child groups) exposure pathways and the associated assessment methods included in REx. The name of the algorithm representing each assessment method is provided in parenthesis alongside the method.

ADULT

During Application

Dermal
Unit Exposure, Area Treated   (Dermal 101)
Unit Exposure, Amount of Formulation Used   (Dermal 102)

Inhalation
Unit Exposure, Area Treated   (Inhalation 101)
Unit Exposure, Amount of Formulation Used   (Inhalation 102)

Dermal + Inhalation
Unit Exposure, Area Treated   (Multiple 101)
Unit Exposure, Amount of Formulation Used   (Multiple 102)

Post Application

Dermal
Transfer Coefficient (Residue)   (Dermal 103)
Transfer Coefficient (Area Treated)   (Dermal 105)
Transfer Factor (Residue)   (Dermal 107)
Transfer Factor (Area Treated)   (Dermal 109)
Fraction Transferred   (Dermal 111)
Flux Rate   (Dermal 113)
Water Concentration   (Dermal 115)
Film Thickness (DERMAL Model)   (Dermal 117)

Ingestion: Water
Water Concentration   (Ingestion 106)

Inhalation
Indoor Air Concentration   (Inhalation 103)
Outdoor Air Concentration   (Inhalation 105)

CHILD

Post Application

Dermal
Transfer Coefficient (Residue) (Dermal 104)
Transfer Coefficient (Area Treated) (Dermal 106)
Transfer Factor (Residue) (Dermal 108)
Transfer Factor (Area Treated) (Dermal 110)
Fraction Transferred (Dermal 112)
Flux Rate (Dermal 114)
Water Concentration (Dermal 116)
Film Thickness (DERMAL Model) (Dermal 118)

Ingestion: Granules/Pellets (Formulation)
Granules/Pellets (Formulation) (Ingestion 101)

Ingestion: Grass/Plants
Grass/Plants (Ingestion 102)

Ingestion: Soil
Soil (Ingestion 103)

Ingestion: Hand-To-Mouth Transfer
Mass Balance (Ingestion 104)
Fraction Transferred (Ingestion 109)
EPA SOPs Method (Ingestion 110)

Ingestion: Paint Chips
Paint Chips (Ingestion 105)

Ingestion: Water
Water Concentration (Ingestion 107)

Ingestion: Flux rate
Flux Rate (Ingestion 108)

Inhalation
Indoor Air Concentration (Inhalation 104)
Outdoor Air Concentration (Inhalation 106)

4.0   INPUTS

4.1   GENERAL (scenario independent)

Exposure	Clothing Penetration Fraction (Uncovered)	*unitless*
	Clothing Penetration Fraction (Covered)	*unitless*
	Ingestion Rate (Granules/Pellets) (Child)	*g/day*
	Ingestion Rate (Grass/Plants) (Child)	*cm^2/day*
	Ingestion Rate (Soil) (Child)	*mg/day*
	Ingestion Rate (Paint Chips) (Child)	*mg/day*
	Ingestion Rate (Water) (Adult)	*L/hr*
	Ingestion Rate (Water) (Child)	*L/hr*
	Transfer Efficiency (Hand-To-Mouth) (per Contact) (Child)	*unitless*
	Fraction Transferred (Hand-To-Mouth) (Total) (Child)	*unitless*
	Reference Duration	*day*
Dose	Fraction Absorbed (Dermal + Inhalation) (During Application)	*unitless*
	Fraction Absorbed (Dermal)	*unitless*
	Fraction Absorbed (Ingestion)	*unitless*
	Fraction Absorbed (Inhalation)	*unitless*
	NOEL (Dermal) (Applied Dose)	*mg/kg/day*
	NOEL (Ingestion) (Applied Dose)	*mg/kg/day*
	NOEL (Inhalation) (Applied Dose)	*mg/kg/day*
	NOEL (Absorbed Dose) (Systemic)	*mg/kg/day*
Human Factors	Area (Hands) (Uncovered) (Adult)	*cm^2*
	Area (Hands) (Covered) (Adult)	*cm^2*
	Area (Upper Body) (Uncovered) (Adult)	*cm^2*
	Area (Upper Body) (Covered) (Adult)	*cm^2*
	Area (Lower Body) (Uncovered) (Adult)	*cm^2*
	Area (Lower Body) (Covered) (Adult)	*cm^2*
	Area (Feet) (Uncovered) (Adult)	*cm^2*
	Area (Feet) (Covered) (Adult)	*cm^2*
	Area (Hands) (Uncovered) (Child)	*cm^2*
	Area (Hands) (Covered) (Child)	*cm^2*
	Area (Upper Body) (Uncovered) (Child)	*cm^2*
	Area (Upper Body) (Covered) (Child)	*cm^2*
	Area (Lower Body) (Uncovered) (Child)	*cm^2*
	Area (Lower Body) (Covered) (Child)	*cm^2*
	Area (Feet) (Uncovered) (Child)	*cm^2*
	Area (Feet) (Covered) (Child)	*cm^2*
	Area (Total) (Adult)	*cm^2*
	Area (Total) (Child)	*cm^2*
	Area (Hands) (Hand-To-Mouth) (Child)	*cm^2*
	Contact Frequency (Hand-To-Mouth) (Child)	*events/hr*
	Inhalation Rate (Adult)	*m^3/hr*
	Inhalation Rate (Child)	*m^3/hr*
	Body Weight (Adult)	*kg*
	Body Weight (Child)	*kg*

4.2 SPECIFIC (scenario dependent)

Source		
	Application (AI per Area Treated)	*lb ai/acre*
	Application (AI per Amount of Formulation Used)	*lb ai/gal*
	Area Treated	*acre*
	Amount of Formulation as Used (By Volume)	*gal*
	Amount of Formulation as Used (By Weight)	*mg*
	Fraction AI in Formulation as Used	*unitless*
	Density of Formulation	g/cm^3

Environment		
	Air concentration (Indoor) of AI	$microg/m^3$
	Dilution factor (Outdoor air)	*unitless*
	Volume of air (Outdoor, imaginary)	m^3
	Concentration of AI in Water	mg/m^3
	Permeability Coefficient	*cm/hr*
	Flux Rate of AI through Impregnated Material	$mg/m^2/day$
	Fraction Transferred to Whole Body (Dermal)	*unitless*
	Fraction AI available (Ingestion)	*unitless*
	Transferable Residue (Surface) (Environment/Pet)	mg/cm^2
	Soil Density (Outdoor)	g/cm^3
	Thickness of Effective Soil Layer	*cm*
	Ground Cover (Grass/Plants)	g/cm^2
	Fraction AI Dislodgeable from Surface (Environment/Pet)	*unitless*
	Fraction AI Dislodgeable from Grass/Plants	*unitless*
	Fraction AI Dislodgeable from Soil	*unitless*
	Fraction AI in Paint Chips	*unitless*
	Fraction AI Dissipated Daily	*unitless*

Exposure		
	Unit Exposure (Dermal + Inhalation) (During Application)	*mg/lb ai*
	Unit Exposure (Dermal) (During Application)	*mg/lb ai*
	Unit Exposure (Inhalation) (During Application)	*mg/lb ai*
	Film Thickness of Formulation on Dermal Area	*cm*
	Transfer Coefficient (Dermal) (Adult)	cm^2/hr
	Transfer Coefficient (Dermal) (Child: age > 6)	cm^2/hr
	Transfer Coefficient (Dermal) (Child: 1<age<6)	cm^2/hr
	Transfer Coefficient (Dermal) (Child: age < 1)	cm^2/hr
	Fraction Transferred to Hand (Dermal)	*unitless*
	Transfer Factor - Hands (Uncovered)	*unitless*
	Transfer Factor - Hands (Covered)	*unitless*
	Transfer Factor - Upper Body (Uncovered)	*unitless*
	Transfer Factor - Upper Body (Covered)	*unitless*
	Transfer Factor - Lower Body (Uncovered)	*unitless*
	Transfer Factor - Lower Body (Covered)	*unitless*
	Transfer Factor - Feet (Uncovered)	*unitless*
	Transfer Factor - Feet (Covered)	*unitless*
	Area Exposed (Film Thickness) (Adult)	cm^2
	Area Exposed (Film Thickness) (Child: age > 6)	cm^2
	Area Exposed (Film Thickness) (Child: 1 < age < 6)	cm^2
	Area Exposed (Film Thickness) (Child: age < 1)	cm^2
	Area Contacted with Imp Material (Adult)	cm^2
	Area Contacted with Imp Material (Child: age>6)	cm^2
	Area Contacted with Imp Material (Child: 1<age<6)	cm^2
	Area Contacted with Imp Material (Child: age<1)	cm^2
	Area Mouthed with Imp Mat (Child: age>6)	cm^2

Area Mouthed with Imp Mat (Child: 1<age<6)		cm^2
Area Mouthed with Imp Mat (Child: age<1)		cm^2
Exposure Duration (Adult)		hr/day
Exposure Duration (Child: age > 6)		hr/day
Exposure Duration (Child: 1 < age < 6)		hr/day
Exposure Duration (Child: age < 1)		hr/day
Exposure Duration (Hand-To-Mouth) (Child: age > 6)		hr
Exposure Duration (Hand-To-Mouth) (Child: 1 < age < 6)		hr
Exposure Duration (Hand-To-Mouth) (Child: age < 1)		hr
Exposure Duration (Impregnated Material) (Adult)		hr
Exposure Duration (Impregnated Material) (Child: age>6)		hr
Exposure Duration (Impregnated Material) (Child: 1<age<6)		hr
Exposure Duration (Impregnated Material) (Child: age<1)		hr
Exposure Duration (Water) (Adult)		hr
Exposure Duration (Water) (Child: age > 6)		hr
Exposure Duration (Water) (Child: 1 < age < 6)		hr
Exposure Duration (Water) (Child: age < 1)		hr
t (= Post Application Day)		day

5.0   ALGORITHMS

5.1   Exposure Pathway: *Dermal*

Methods:

Dermal 101
Unit Exposure, Area Treated

Dermal 102
Unit Exposure, Amount of Formulation Used

Dermal 103/104
Transfer Coefficient (Residue)

Dermal 105/106
Transfer Coefficient (Area Treated)

Dermal 107/108
Transfer Factor (Residue)

Dermal 109/110
Transfer Factor (Area Treated)

Dermal 111/112
Fraction Transferred

Dermal 113/114
Flux Rate

Dermal 115/116
Water Concentration

Dermal 117/118
Film Thickness (DERMAL Model)

Dermal 101

Method: Unit exposure, Area treated

Application: During
Receptor: Adult

Inputs

Source	Application (AI per Area Treated)	$kg\ ai/m^2$
	Area Treated	m^2
Exposure	Unit Exposure (Dermal) (During application)	$mg/kg\ ai$
	Reference Duration	day
Human Factor	Body Weight (Adult)	kg

Calculation (Exposure$_{Adult}$: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Dermal} \times (Application)_{Area\,Treated} \times (Area\ Treated)}{(Re\,ference\ Duration) \times (Body\ Weight)_{Adult}}$$

Dermal 102

Method: Unit exposure, Amount of Formulation Used

Application: During
Receptor: Adult

Inputs

Source	Application (Amount of AI Used)	$kg\ ai/m^3$
	Amount of Formulation Used	m^3
Exposure	Unit Exposure (Dermal) (During Application	$mg/kg\ ai$
	Reference Duration	day
Human Factor	Body Weight (Adult)	kg

Calculation (Exposure$_{Adult}$: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Dermal} \times (Application)_{Amt\ FormUsed} \times (Amount\ of\ Form\ Used)}{(Re\ ference\ Duration) \times (Body\ Weight)_{Adult}}$$

Dermal 103/104

Method: Transfer Coefficient (Residue)

Application: Post
Receptor: Adult / Child

Inputs

Environment	Transferable Residue (Surface) (Environment/Pet)	mg/cm^2
	Fraction Dissipated Daily	*unitless*
Exposure	Transfer Coefficient (Adult/Child)	cm^2/hr
	Fraction Transferred to Hand (Dermal) (Child)	*unitless*
	t (= Post Application Day)	*day*
	Exposure Duration (Adult/Child)	*hr/day*
Human Factor	Body Weight (Adult/Child)	*kg*

Calculation (Transferable Residue: mg/cm^2; Exposure$_{Adult/Child}$: *mg/kg/day*; Exposure$_{Hand,Child}$: *mg/day*)

$$Transferable\ Residue_t = (Transferable\ Residue)_{t=0} \times (1 - Fraction\ Dissipated\ Daily)^t$$

$$Exposure_{Adult/Child} = \frac{(Trans\ Residue)_t \times (Transfer\ Coefficient)_{Adult/Child} \times (Exp\ Duration)_{Adult/Child}}{(Body\ Weight)_{Adult/Child}}$$

$$Exposure_{Hand,Child} = (Trans\ Res)_t \times (Trans\ Coeff)_{Child} \times (Frac\ Trans)_{Hand,Child} \times (Exp\ Dur)_{Child}$$

Dermal 105/106

Method: Transfer Coefficient (Area Treated)

Application: Post
Receptor: Adult / Child

Inputs

Source	Application (AI per Area Treated)	$kg\ ai/m^2$
Environment	Fraction AI Dislodgeable in Surface	*unitless*
	Fraction AI Dissipated Daily	*unitless*
Exposure	Transfer Coefficient (Adult/Child)	cm^2/hr
	t (= Post Application Day)	*day*
	Fraction Transferred to Hand (Dermal) (Child)	*unitless*
	Exposure Duration (Adult/Child)	*hr/day*
Human Factor	Body Weight (Adult/Child)	*kg*

Calculation (Transferable Residue: mg/cm^2, Exposure$_{Adult/Child}$: $mg/kg/day$; Exposure$_{Hand,Child}$: mg/day)

$$Trans\ Re\,sidue_t = (Application)_{Area\,Treated} \times (Frac\ AI\ Dislodge) \times (1 - Frac\ Diss\ Daily)^t \times 100$$

$$Exposure_{Adult/Child} = \frac{(Trans\ Re\,sidue)_t \times (Trans\,fer\ Coefficient)_{Adult/Child} \times (Exp\ Duration)_{Adult/Child}}{(Body\ Weight)_{Adult/Child}}$$

$$Exposure_{Hand,Child} = (Trans\ Re\,s)_t \times (Trans\ Coeff)_{Child} \times (Frac\ Trans)_{Hand,Child} \times (Exp\ Dur)_{Child}$$

Dermal 107/108

Method: Transfer Factor (Residue)

Application: Post
Receptor: Adult / Child

Inputs

Environment	Transferable Residue (Surface) (Environment/Pet)	mg/cm^2
	Fraction Dissipated Daily	*unitless*
Exposure	Transfer Factor – Hands (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Hands (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Upper Body (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Upper Body (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Lower Body (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Lower Body (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Feet (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Feet (Covered) (Adult/Child)	*unitless*
	Clothing Penetration Fraction (Uncovered) (Adult/Child)	*unitless*
	Clothing Penetration Fraction (Covered) (Adult/Child)	*unitless*
	Reference Duration	*day*
Human Factor	Surface Area (Hands) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Hands) (Covered) (Adult/Child)	cm^2
	Surface Area (Upper Body) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Upper Body) (Covered) (Adult/Child)	cm^2
	Surface Area (Lower Body) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Lower Body) (Covered) (Adult/Child)	cm^2
	Surface Area (Feet) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Feet) (Covered) (Adult/Child)	cm^2
	Body Weight (Adult/Child)	*kg*

Calculation (Transferable Residue: mg/cm^2; Exposure$_{Adult/Child}$: $mg/kg/day$; Exposure$_{Hand,Child}$: mg/day)

$$Transferable\ Re\,sidue_t = (Transferable\ Re\,sidue)_{t=0} \times (1 - Fraction\ Dissipated\ Daily)^t$$

$$Exposure_{Adult/Child} = \frac{\sum\{(Trans\ Factor) \times (Surf\ Area)_{Adult/Child} \times (Cloth\ Pen\ Factor)\} \times (Trans\ Re\,s)_t}{(Re\,ference\ Duration) \times (Body\ Weight)_{Adult/Child}}$$

- summation across all body parts (uncovered and covered)

$$Exposure_{Hand,Child} = \frac{\sum\{(Trans\ Fact) \times (Surf\ Area)_{Child} \times (Cloth\ Pen\ Factor)\} \times (Trans\ Re\,s)_t}{(Re\,ference\ Duration)}$$

- summation across hands (uncovered and covered)

Dermal 109/110

Method: Transfer Factor (Area Treated)

Application: Post
Receptor: Adult / Child

Inputs

Source	Application (AI per Area Treated)	$kg\ ai/m^2$
Environment	Fraction AI Dislodgeable in Surface	*unitless*
	Fraction AI Dissipated Daily	*unitless*
Exposure	Transfer Factor – Hands (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Hands (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Upper Body (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Upper Body (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Lower Body (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Lower Body (Covered) (Adult/Child)	*unitless*
	Transfer Factor – Feet (Uncovered) (Adult/Child)	*unitless*
	Transfer Factor – Feet (Covered) (Adult/Child)	*unitless*
	Clothing Penetration Fraction (Uncovered)	*unitless*
	Clothing Penetration Fraction (Covered)	*unitless*
	t (= Post Application Day)	*day*
	Reference Duration	*day*
Human Factor	Surface Area (Hands) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Hands) (Covered) (Adult/Child)	cm^2
	Surface Area (Upper Body) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Upper Body) (Covered) (Adult/Child)	cm^2
	Surface Area (Lower Body) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Lower Body) (Covered) (Adult/Child)	cm^2
	Surface Area (Feet) (Uncovered) (Adult/Child)	cm^2
	Surface Area (Feet) (Covered) (Adult/Child)	cm^2
	Body Weight (Adult/Child)	*kg*

Calculation (Transferable Residue: mg/cm^2, Exposure$_{Adult/Child}$: $mg/kg/day$; Exposure$_{Hand,Child}$: mg/day)

$$Trans\ Residue_t = (Application)_{Area\,Treated} \times (Frac\ AI\ Dislodge) \times (1 - Frac\ Diss\ Daily)^t \times 100$$

$$Exposure_{Adult/Child} = \frac{\sum\{(Trans\ Factor) \times (Surf\ Area)_{Adult/Child} \times (Cloth\ Pen\ Factor)\} \times (Trans\ Res)_t}{(Reference\ Duration) \times (Body\ Weight)_{Adult/Child}}$$

- summation across all body parts (uncovered and covered)

$$Exposure_{Hand,Child} = \frac{\sum\{(Trans\ Fact) \times (Surf\ Area)_{Child} \times (Cloth\ Pen\ Factor)\} \times (Trans\ Res)_t}{(Reference\ Duration)}$$

- summation across hands (uncovered and covered)

Dermal 111/112

Method: Fraction Transferred

Application: Post
Receptor: Adult / Child

Inputs

Source	Amount of Formulation as Used (By Weight)	*mg*
	Fraction AI in Formulation	*unitless*
Environment	Fraction AI Dislodgeable on Surface (Environment/Pet)	*unitless*
	Fraction AI Dissipated Daily	*unitless*
Exposure	Fraction Transferred to Whole Body (Dermal)	*cm^2/hr*
	Fraction Transferred to Hand (Dermal) (Child)	*unitless*
	t (= Post Application Day)	*day*
	Reference Duration	*day*
Human Factor	Body Weight (Adult/Child)	*kg*

Calculations (Transferable Residue: *mg*; Exposure$_{Adult/Child}$: *mg/kg/day*; Exposure$_{Hand,Child}$: *mg/day*)

$$Trans\ Residue_t = (Amt\ Form\ Used) \times (Frac\ AI\ Form) \times (Frac\ AI\ Dislodge) \times (1 - Frac\ Diss\ Daily)^t$$

$$Exposure_{Adult/Child} = \frac{(Transferable\ Residue)_t \times (Fraction\ Transferred)_{Whole\ Body,Adult/Child}}{(Body\ Weight)_{Adult/Child}}$$

$$Exposure_{Hand,Child} = (Transferable\ Residue)_t \times (Fraction\ Transferred)_{Hand,Child}$$

Dermal 113/114

Method: Flux Rate

Application: Post
Receptor: Adult / Child

Inputs

Environment	Flux Rate of AI through Impregnated Material	$mg/m^2/day$
	Fraction Dissipated Daily	unitless
Exposure	Exposure Duration (To Impregnated Material) (Adult/Child)	hr
	Fraction Transferred to Hand (Dermal)	unitless
	t (= Post Application Day)	day
	Reference Duration	day
Human Factor	Surface Area Contact with Impregnated Material (Ad/ Ch)	cm^2
	Body Weight (Adult/Child)	kg

Calculations (Exposure$_{Adult/Child}$: *mg/kg/day*; Exposure$_{Hand,Child}$: *mg/day*)

$$Exposure_{Adult/Child} = (Flux\ Rate\ AI) \times (1 - Frac\ Diss\ Daily)^t$$
$$\times \frac{(Surface\ Area)_{Contact,Adult/Child} \times (Exposure\ Duration)_{Adult/Child}}{(Reference\ Duration) \times (Body\ Weight)_{Adult/Child} \times (10000 \times 24)}$$

$$Exposure_{Hand,Child} = (Flux\ Rate\ AI) \times (1 - Fraction\ Dissipated\ Daily)^t$$
$$\times \frac{(Surface\ Area)_{Contact,Child} \times (Fraction\ Transferred)_{Hand,Child} \times (Exposure\ Duration)_{Child}}{(Reference\ Duration) \times (10000 \times 24)}$$

Dermal 115/116

Method: Water Concentration

Application: Post
Receptor: Adult / Child

Inputs

Environment	Concentration of AI Pool Water	*mg/m³*
	Fraction Dissipated Daily	*unitless*
	Permeability Coefficient	*cm/hr*
Exposure	Exposure Duration (Adult/Child)	*hr*
	t (= Post Application Day)	*day*
	Reference Duration	*day*
Human Factor	Surface Area (Whole Body) (Adult/Child)	*cm²*
	Body Weight (Adult/Child)	*kg*

Calculations (Exposure$_{Adult/Child}$: *mg/kg/day*)

$$Exposure_{Adult/Child} = (Conc\ AI\ Water) \times (1 - Fraction\ Dissipated\ Daily)^t \times (Permeability\ Coeff)$$
$$\times \frac{(Surface\ Area)_{Contact,Adult/Child} \times (Exposure\ Duration)_{Adult/Child}}{(Reference\ Duration) \times (Body\ Weight)_{Adult/Child} \times (1000000)}$$

Dermal 117/118

Method: Film Thickness (DERMAL Model)

Application: Post
Receptor: Adult / Child

Inputs

Environment	Density of Formulation	mg/cm^3
	Fraction of AI in Formulation	unitless
Exposure	Film thickness of Formulation on Dermal Area	cm
	Fraction Transferred to Hand (Dermal) (Child)	unitless
	Reference Duration	day
Human Factor	Surface Area (Exposed to Formulation) (Adult/Child)	cm^2
	Body Weight (Adult/Child)	kg

Calculations (Exposure$_{Adult/Child}$: *mg/kg/day;* Exposure$_{Hand,Child}$: *mg/day*)

$$Exposure_{Adult/Child} = \frac{(Density\ Form) \times (Frac\ AI\ Form) \times (Film\ Thick) \times (Surf\ Area)_{Exposed,Adult/Child}}{(Re\ ference\ Duration) \times (Body\ Weight)_{Adult/Child}}$$

$$Exposure_{Hand,Child} = (Density\ Formulation) \times (Fraction\ AI\ Formulation) \times (Film\ Thickness)$$

$$\times \frac{(Surface\ Area)_{Exposed,Child} \times (Fraction\ Transferred)_{Hand,Child}}{(Re\ ference\ Duration)}$$

5.2   Exposure Pathway: *Ingestion*

Methods:

Ingestion 101
        Granules/Pellets (Formulation)

Ingestion 102
        Grass/Plants

Ingestion 103
        Soil

Ingestion 104
        Hand-To-Mouth Transfer: Mass Balance

Ingestion 105
        Paint Chips

Ingestion 106/107
        Water Concentration (Swimming Pool)

Ingestion 108
        Flux Rate

Ingestion 109
        Hand-To-Mouth Transfer: Fraction Transferred

Ingestion 110
        Hand-To-Mouth Transfer: EPA SOP

Ingestion 101

Method: Granules/Pellets (Formulation)

Application: Post
Receptor: Child

Inputs

Source	Fraction AI in Formulation as Used	*unitless*
Exposure	Ingestion Rate (Granules/Pellets) (Child)	*mg/day*
Human Factor	Body Weight (Child)	*kg*

Calculation (Exposure_{Child}: *mg/kg/day*)

$$Exposure_{Child} = \frac{(Ingestion\ Rate)_{Granules/\ Pellets,Child} \times (Fraction\ AI\ in\ Granules\ /\ Pellets)}{(Body\ Weight)_{Child}}$$

Ingestion 102

Method: Grass/Plants

Application: Post
Receptor: Child

Inputs

Source	Application (AI per Area treated)	*kg ai/m^2*
Environment	Ground Cover (Grass/Plants)	*g/cm^2*
	Fraction AI Dislodgeable from Grass/Plants	*unitless*
	Fraction AI Dissipated Daily	*unitless*
Exposure	Ingestion Rate (Grass/Plants) (Child)	*mg/day*
	t (= Post Application Day)	*day*
Human Factor	Body Weight (Child)	*kg*

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Re\,sidue_{Grass/Plants} = \frac{(Application)_{Area\,Treated} \times (Frac\ AI\ Grass/Plants) \times (1 - Frac\ Diss\ Daily)^t}{(Ground\ Cover)}$$

$$Exposure_{Child} = \frac{(Re\,sidue)_{Grass/Plants} \times (Ingestion\ Rate)_{Grass/Plants,Child}}{(Body\ Weight)_{Child}}$$

Ingestion 103

Method: Direct: Soil

Application: Post
Receptor: Child

Inputs

Source	Application (Area Treated)	$kg\ ai/m^2$
Environment	Soil Density (Outdoor)	g/cm^3
	Thickness of Effective Soil Layer	cm
	Fraction AI Dislodgeable from Soil	unitless
	Fraction AI Dissipated Daily	unitless
Exposure	Ingestion Rate (Soil) (Child)	mg/day
	t (= Post Application Day)	day
Human Factor	Body Weight (Child)	kg

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Re\,sidue_{Soil} = \frac{(Application)_{Area\,Treated} \times (Fraction\ AI\ Soil) \times (1 - Fraction\ Dissipated\ Daily)^t}{(Soil\ Density) \times (Thickness\ Soil\ Layer)}$$

$$Exposure_{Child} = \frac{(Re\,sidue)_{Soil} \times (Ingestion\ Rate)_{Soil,Child}}{(Body\ Weight)_{Child}}$$

Ingestion 104

Method: Hand-To-Mouth Transfer (Mass Balance)

Application: Post
Receptor: Child

Inknputs

Exposure	Hand Dermal Exposure (Child)	*mg/day*
	Contact Frequency (Hand-To-Mouth) (Child)	*events/hr*
	Transfer Efficiency (Hand-To-Mouth) (per Contact) (Child)	*unitless*
	Exposure Duration (Hand-To-Mouth) (Child)	*hr*
Human Factor	Body Weight (Child)	*kg*

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Transfer\ Factor_{Hand-To-Mouth} = (Transfer\ Eff) \times \sum_{n=1}^{[(Contact\ Freq) \times (Exp\ Duration)]} [1 - (Transfer\ Eff)]^{n-1}$$

$$Exposure_{Child} = \frac{(Exposure)_{Hand(Dermal),Child} \times (Transfer\ Factor)_{Hand-To-Mouth}}{(Body\ Weight)_{Child}}$$

Ingestion 105

Method: Paint Chips

Application: Post
Receptor: Child

Inputs

Source	Fraction AI in Paint Chips	*unitless*
	Fraction AI (in Paint Chips) available for ingestion	*unitless*
Exposure	Ingestion Rate (Paint Chips) (Child)	*mg/day*
Human Factor	Body Weight (Child)	*kg*

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Exposure_{Child} = \frac{(Ingestion\ Rate)_{Paint\ Chips,Child} \times (Frac\ AI\ in\ Paint\ Chips) \times (Frac\ AI\ Available)}{(Body\ Weight)_{Child}}$$

Ingestion 106/107

Method: Water Concentration (Swimming Pool)

Application: Post
Receptor: Adult / Child

Inputs

Source	Water Concentration (Swimming Pool)	*mg ai/m³*
Exposure	Ingestion Rate (Pool Water) (Adult/Child)	*m³/hr*
	Exposure Duration (in Pool) (Adult/Child)	*hr*
	Reference Duration	*day*
Human Factor	Body Weight (Adult/Child)	*kg*

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Exposure_{Adult/Child} = \frac{(Water\ Conc)_{Swimming\ Pool} \times (Ing\ Rate)_{Pool\ Water, Adult/Child} \times (Exp\ Dur)_{Adult/Child}}{(Re\ ference\ Duration) \times (Body\ Weight)_{Adult/Child}}$$

Ingestion 108

Method: Flux Rate

Application: Post
Receptor: Child

Inputs

Source	Flux Rate of AI	$mg/cm^2/day$
Exposure	Surface Area (Impregnated Material) Mouthed (Child)	cm^2
Human Factor	Body Weight (Child)	kg

Calculation (Exposure$_{Child}$: *mg/kg/day*)

$$Exposure_{Child} = \frac{(Flux\ Rate\ AI) \times (Surface\ Area\ Im\ pregnated\ Material)_{Mouthed}}{(Body\ Weight)_{Child}}$$

Ingestion 109

Method: Hand-To-Mouth Transfer (Fraction Transferred)

Application: Post
Receptor: Child

Inputs

Exposure	Hand Exposure (Dermal) (Child)	*mg/day*
	Fraction Transferred (Hand-To-Mouth) (Based on Total Contacts Per Day) (Child)	*unitless*
Human Factor	Body Weight (Child)	*kg*

Calculation (Exposure_Child: *mg/kg/day*)

$$Exposure_{Child} = \frac{(Exposure)_{Hand(Dermal),Child} \times (Fraction\ Transferred)_{Hand-To-Mouth}}{(Body\ Weight)_{Child}}$$

Ingestion 110

Method: Hand-To-Mouth Transfer (EPA SOP)

Application: Post
Receptor: Child

Inputs

Source	Application (Area Treated)	$kg\ ai/m^2$
Environment	Fraction AI Dislodgeable in Surface	unitless
	Fraction AI Dissipated Daily	unitless
Exposure	t (= Post Application Day)	day
	Hand-To-Mouth Contact Frequency (Child)	events/hr
	Exposure Duration (Child)	hr
	Surface Area of Hands Mouthed (Child)	cm^2
Human Factor	Body Weight (Child)	kg

Calculation (Transferable Residue: mg/cm^2, Exposure$_{Child}$: $mg/kg/day$)

$$Trans\ Residue_t = (Application)_{Area\,Treated} \times (Frac\ AI\ Dislodge) \times (1 - Frac\ Diss\ Daily)^t \times 100$$

$$Exposure_{Child} = \frac{(Trans\ Res)_t \times (HtoM\ Cont\ Freq)_{Child} \times (Surf\ Area\ Mouthed)_{Hands,Child} \times (Exp\ Dur)_{Child}}{(Body\ Weight)_{Child}}$$

5.3   Exposure Pathway: Inhalation

Methods:

Inhalation 101
Unit Exposure, Area Treated

Inhalation 102
Unit Exposure, Amount of Formulation Used

Inhalation 103/104
Indoor Air Concentration

Inhalation 105/106
Outdoor Air Concentration

Inhalation 101

Method: Unit exposure, Area treated

Application: During
Receptor: Adult

Inputs

Source	Application (AI per Area Treated)	$kg\ ai/m^2$
	Area Treated	m^2
Exposure	Unit Exposure (Inhalation) (During Application	$mg/kg\ ai$
	Reference Duration	day
Human Factor	Body Weight (Adult)	kg

Calculation (Exposure$_{Adult}$: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Inhalation} \times (Application)_{Area\,Treated} \times (Area\ Treated)}{(Re\,ference\ Duration) \times (Body\ Weight)_{Adult}}$$

Inhalation 102

Method: Unit exposure, Amount of Formulation Used

Application: During
Receptor: Adult

Inputs

Source	Application (Amount of AI in Formulation)	*kg ai/m^3*
	Amount of Formulation Used	*m^3*
Exposure	Unit Exposure (Inhalation) (During Application)	*mg/kg ai*
	Reference Duration	*day*
Human Factor	Body Weight	*kg*

Calculation (Exposure$_{Adult}$: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Inhalation} \times (Application)_{Amt\ FormUsed} \times (Amount\ of\ Form\ Used)}{(Re\,ference\ Duration) \times (Body\ Weight)_{Adult}}$$

Inhalation 103/104

Method: Indoor Air Concentration

Application: Post
Receptor: Adult / Child

Inputs

Environment	Air concentration of AI (Indoor)	mg/m^3
Exposure	Exposure Duration (Adult/Child)	hr/day
Human Factor	Inhalation Rate (Adult/Child)	m^3/hr
	Body Weight (Adult/Child)	kg

Calculation (Exposure_Adult/Child: *mg/kg/day*)

$$Exposure_{Adult/Child} = \frac{(Air\ Conc\ AI) \times (Inhalation\ Rate)_{Adult/Child} \times (Exposure\ Duration)_{Adult/Child}}{(Body\ Weight)_{Adult/Child}}$$

Inhalation 105/106

Method: Outdoor Air Concentration

Application: Post
Receptor: Adult / Child

Inputs

Source	Amount of Formulation (As Used) (By Volume)	m^3
	Fraction of AI in Formulation (As Used)	unitless
	Density of Formulation	mg/m^3
Environment	Dilution Factor (Outdoor Air)	unitless
	Volume (Outdoor, Imaginary)	m^3
Exposure	Exposure Duration (Adult/Child)	hr/day
Human Factor	Inhalation Rate (Adult/Child)	m^3/hr
	Body Weight (Adult/Child)	kg

Calculation (Exposure$_{Adult/Child}$: *mg/kg/day*)

$$Air\ Concentration_{Outdoor} = \frac{(Amt\ Form) \times (Frac\ AI\ Form) \times (Density\ Form) \times (Dilution\ Factor)_{Outdoor}}{(Volume)_{Outdoor}}$$

$$Exposure_{Adult/Child} = \frac{(Air\ Conc)_{Outdoor} \times (Inhalation\ Rate)_{Adult/Child} \times (Exposure\ Duration)_{Adult/Child}}{(Body\ Weight)_{Adult/Child}}$$

5.4   Exposure Pathway: Multiple (Dermal + Inhalation)

Methods:

Multiple (Dermal+Inhalation) 101
Unit Exposure, Area Treated

Multiple (Dermal+Inhalation) 102
Unit Exposure, Amount of Formulation Used

Multiple 101

Method: Unit exposure, Area treated

Application: During
Receptor: Adult

Inputs

Source	Application (AI per Area Treated)	$kg\ ai/m^2$
	Area Treated	m^2
Exposure	Unit Exposure (Dermal + Inhalation) (During Application)	$mg/kg\ ai$
	Reference Duration	day
Human Factor	Body Weight (Adult)	kg

Calculation (Exposure_{Adult}: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Dermal+Inhalation} \times (Application)_{Area\ Treated} \times (Area\ Treated)}{(Re\ ference\ Duration) \times (Body\ Weight)_{Adult}}$$

Multiple 102

Method: Unit exposure, Amount of Formulation Used

Application: During
Receptor: Adult

Inputs

Source	Application (Amount of AI in Formulation)	*kg ai/m³*
	Amount of Formulation Used	*m³*
Exposure	Unit Exposure (Dermal + Inhalation) (During Application)	*mg/kg ai*
	Reference Duration	*day*
Human Factor	Body Weight (Adult)	*kg*

Calculation (Exposure$_{Adult}$: *mg/kg/day*)

$$Exposure_{Adult} = \frac{(Unit\ Exposure)_{Dermal+Inhalation} \times (Application)_{Amt\ Form\ Used} \times (Amount\ of\ Form\ Used)}{(Re\ ference\ Duration) \times (Body\ Weight)_{Adult}}$$